

Environmental Radiation Monitoring System

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1. Introduction

In order to ascertain conditions near the perimeter of a supervised area at a nuclear power plant or other facility that uses radiation, environmental radiation monitoring systems operate to continuously measure the environmental gamma-ray dose rate.

Moreover, in recent years, in order to provide the general public with a better understanding of the operation of nuclear power plants, measurement data is being reported publicly and sent to nuclear environmental monitoring facilities administered by local municipalities, and this dissemination of information

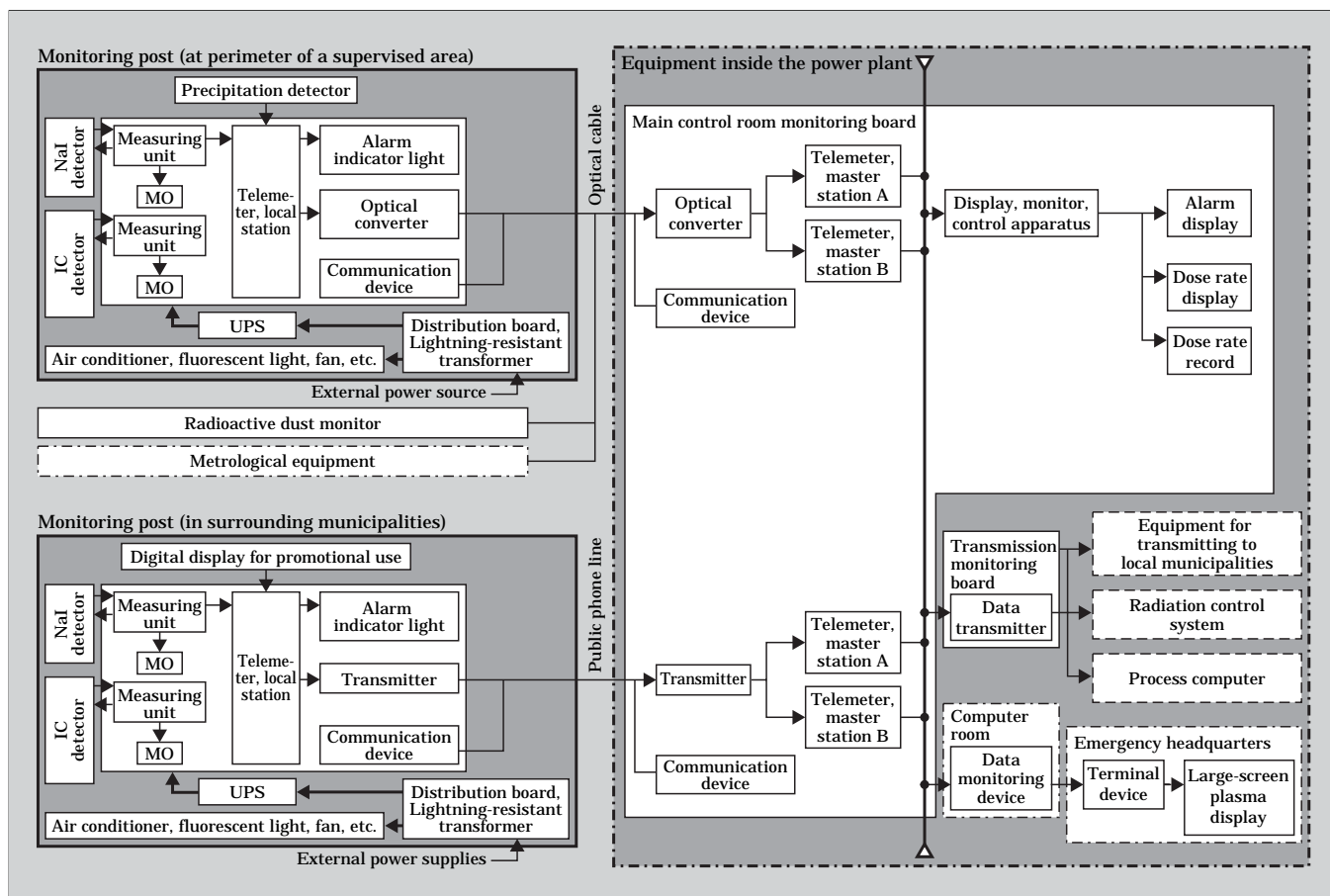
has become an important service.

This paper describes Fuji Electric's latest environmental radiation monitoring system.

2. System Configuration

The system is configured from a monitoring post or meteorological equipment installed at the perimeter of a supervised area at a nuclear power plant, a telemeter that transmits measurement data to a main control room in the nuclear power plant, and a central data monitoring device that displays and controls the measurement data and alarms. Figure 1 shows an

Fig.1 System configuration (example)



example configuration of the system.

3. Monitoring Post

A monitoring post has a structure that houses a dose rate measuring device for continuous measurement of the environmental gamma-ray dose rate. Moreover, a structure equipped with both a dose rate measuring device and a radioactive dust monitor for measuring the concentration of airborne radioactive dust is known as a monitoring station. Monitoring posts and monitoring stations are generally installed at 3 to 9 sites near the perimeter of a supervised area of a nuclear power plant, and at 3 to 22 sites in the surrounding communities.

3.1 Environmental gamma-ray dose rate measuring device

In accordance with the guidelines for environmental radiation monitoring, the environmental gamma-ray dose rate is measured over a wide range, from the background (BG) level (several tens of nGy/h) to 10^8 nGy/h. Measurement is therefore implemented with the combination of a NaI (TI) scintillation detector (see Fig. 2) for measuring low dose rates and a spherical ionization chamber detector (see Fig. 3) for

Fig.2 NaI (TI) scintillation detector



Fig.3 Spherical ionization chamber detector



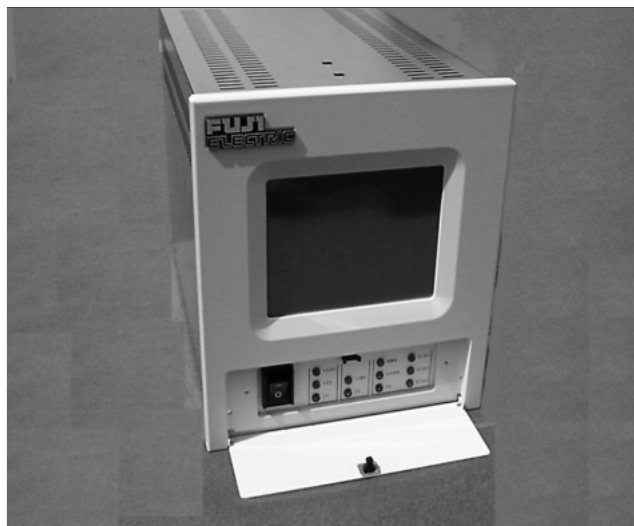
measuring high dose rates.

Digitalization and small, high-density packaging technology enable the dose rate measuring device to be realized with a simple basic configuration that combines a detector unit and a measurement unit (having dimensions of approximately 21 (W) \times 23 (H) \times 30 (D) (cm)) (see Fig. 4) to achieve space savings and high reliability.

The detector unit of the low dose rate measurement system is equipped with an NaI (TI) scintillator, a photomultiplier, an amplifier circuit, a high voltage circuit and a temperature compensating circuit, and is capable of outputting standardized pulse signals from the detector, without any temperature dependence. The measurement unit has two CPU boards, one board is for measurement use and contains an approximately 6-inch thin film transistor (TFT) color display and an energy compensation circuit, and the other board is for displaying, transmitting and storing the measured data. Because this measurement system uses an energy compensation method of spectral weighting with a digital weighting method (DWM), the conversion into a dose rate can be accomplished without decreasing the count precision, and a spectral data analysis function is able to identify radioisotopes from the gamma-ray energy information. Spectral data is also transmitted to the main control room at fixed intervals so that analysis can be performed offsite.

The detector unit of the high dose rate measurement system is equipped with an ionizing chamber, an amplifier circuit, a voltage frequency translation circuit and a high-voltage circuit. The measuring unit counts pulse signals sent from the detector unit and displays dose rate data. For this measurement system, some spherical ionization chamber detectors were also made from aluminum material, which has a smaller specific gravity than the conventional stainless steel material, enabling improved measurement accuracy of gamma-rays in the low energy range of less than

Fig.4 Measurement part of dose rate measuring device



400 keV.

The method of onsite recording of measurement data has changed from the conventional method of data recording with a data logger to a method in which measurement values are digitized and then stored on an optical disk. This method makes it possible to ascertain measurement value fluctuations, record the device status, and expand the data storage period, while also enabling data analysis to be performed simply with the use of a personal computer.

The high dose rate measurement system normally uses a spherical ionization chamber detector, but in order to provide the low dose rate measurement system with the capability to compensate measurements when trouble arises, a wide range NaI (TI) scintillation detector capable of measuring the range from BG level to 10^8 nGy/h was developed and the system configured. In the low range from BG level to 10^5 nGy/h, this system measures and processes pulse signals from the detector. In the high range above 10^5 nGy/h at which pulses cannot be measured, the system measures and processes an electric current signal that is proportional to the dose rate.

Main specifications of the low range measurement system, the high range measurement system and the wide range NaI measurement system are listed in

Table 1.

3.2 Radioactive dust monitor

The radioactive dust monitor is a device that continuously measures the concentration of radioactive dust in the air. The detector unit measures beta-rays using a plastic scintillation detector, and integrates dust sampler and dust monitor that measures the concentration of dust collected in a paper filter. Also provided is a function that automatically samples radioactive iodine in a charcoal cartridge in cases where the environmental gamma-ray dose rate exceeds a preset alarm value.

The sampling pump uses an inverter to provide constant flow control and enable continuous sampling at the constant flow rate of 250 L/min even in cases when the flow rate fluctuates due to clogging of the paper filter or the like.

3.3 Monitoring station

The monitoring station (see Fig. 5) is assembled from precast autoclaved lightweight concrete (ALC) boards, the use of which shortens the time necessary for construction and reduces cost.

In order to publicly report the environmental radiation measurement data, monitoring stations in-

Table 1 Main specifications

Item	Low-range measurement system	High-range measurement system	Wide-range NaI measurement system
Detector	NaI (TI) scintillation detector	Spherical ionization chamber detector	NaI (TI) scintillation detector (with energy filter)
Detector size	2-inch diameter×2-inch height, etc.	Approx. 14.5 L	2-inch diameter×2-inch height
Measurement range	BG level up to 10^5 nGy/h	BG level up to 10^8 nGy/h	BG level up to 10^8 nGy/h
Reading error	Within ± 10 %	Within ± 10 %	Within ± 20 %
Energy dependency	50 keV to 3 MeV : within ± 10 %	50 to 400 keV : within ± 15 % 0.4 to 3 MeV : within ± 10 %	50 to 100 keV : within ± 20 % 50 keV to 3 MeV : within ± 10 %
Directional dependency	Within ± 10 %	Within ± 3 %	Within ± 10 %
Temperature characteristics (20°C standard)	Within ± 3 %	Within ± 5 %	Within ± 5 %

Fig.5 Appearance of monitoring station



Fig.6 Digital display



stalled in the communities surrounding a power plant are provided with a graphic panel that explains the role of the monitoring post and shows the locations of nearby monitoring posts, and a high-intensity light emitting diode (LED) display (see Fig. 6) that digitally displays the environmental gamma-ray dose rate.

Because the monitoring panel installed inside a monitoring station is a front maintenance-type panel, it can be installed with its rear surface in close proximity to a wall. By eliminating the rear maintenance space that had been necessary in the past, space-savings is achieved inside the monitoring station.

As measures against radiation fluctuation due to radon and thoron, an air blower is provided to ventilate the air in the detector unit and a heat exchanger ventilation apparatus is provided to ventilate the air inside the monitoring station so that there is no change in temperature.

Additionally, a mechanism for transporting detectors mounted on the roof into the monitoring station is provided. Because the spherical ionization chamber detector is particularly heavy, the use of a hoisting machine improves operability and safety.

4. Telemeter

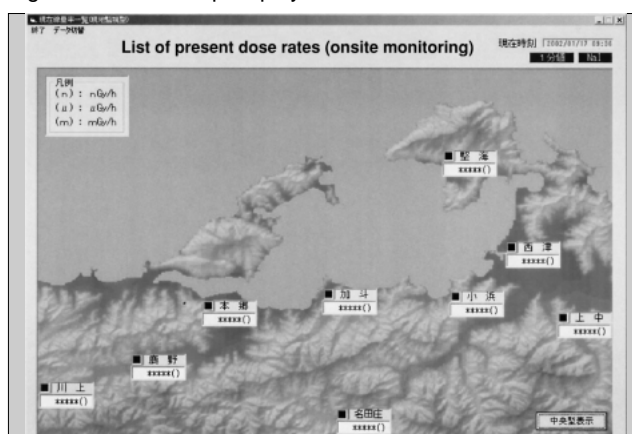
The 24-hour-per-day continuous transmission of data from a monitoring post to the monitoring board in the main control room is implemented via a transmission system in which a programmable controller (MI CREX series), having a proven track record of high reliability, is configured as a telemeter. At monitoring posts near the perimeter of a supervised area at a power plant, optical fiber cable is used in the transmission path in order to prevent erroneous signals caused by the commingling of exogenous noise due to lightning or the like. At monitoring posts in the surrounding communities, public phone lines are used so that a transmission path can be secured easily.

The telemeter uses a broadcast transmission protocol that eliminates the need for the application software to acknowledge the transmission or reception of data. Measurement data from the monitoring post can be refreshed in 1-second cycles, and high-speed and highly reliable transmission is realized.

In consideration of the possible occurrence of a transmission path malfunction, the monitoring post telemeter is provided with the capability to store up to a maximum of 14 days of measurement data (values sampled every 30 seconds) in a memory card. After proper operation is restored, storage data can also be collected from the central data monitoring device or the like.

The main control room's telemeter (master station) that collects measurement data from each monitoring post is implemented as a dual-redundant system in order to avoid data dropout due to device malfunction.

Fig.7 Dose rate map display



This redundancy increases the system reliability.

Additionally, because the telemeter is provided with a computation function for converting a monitoring post's measurement data into the dose rate, and is able to perform what was previously a function of the computer system — the calculation of alarm setting values and conversion of measurement data into scientific values — the system can be simplified.

Furthermore, because the telemeter can expand control through PE link transmission (Fuji Electric's proprietary LAN), and is equipped with communication interfaces for serial communication, Ethernet*¹ and the like, the transmission of measurement data even to nuclear power environmental monitoring facilities administered by local municipalities can be implemented easily.

5. Data Monitoring Device

The data monitoring device that displays data, monitors the system operation status, creates forms, etc. is centrally located, where measurement data from the monitoring posts is collected, stored and then aggregated. The data monitoring device is selectable as a Unix*² server, FA computer, or the like according to the system size, and is designed for 24-hour continuous monitoring.

An example of the main functions is presented below for the case when a Unix server is used as the data monitoring device.

5.1 Screen display

(1) List of present dosage rates

Displays a list of the present values of the dose rate data and meteorological data

(2) Dose rate map display (see Fig. 7)

Displays present values of the dose rate data and meteorological data on a topographic map at the

*1 Ethernet: A registered trademark of Xerox Corp., USA

*2 UNIX: A registered trademark in USA and other countries licensed by X/Open Co. Ltd.

location of the monitoring post

(3) Dose rate trend display

Displays the dose rate data and precipitation data in a trend graph

By displaying the dose rate and precipitation data at the same time, the change in dose rate that accompanies precipitation can be assessed quickly. Also, the scale of the graph's vertical axis can be modified automatically.

(4) Alarm history display

Displays the incidence of and recovery from alarms generated by the system

(5) Alarm display panel

Displays the operating status of the system components in green (normal) or red (alarm generated) above the system configuration schema so that the operating status can be assessed quickly

(6) Spectral data display

Displays the spectral data per station or as a time series in 10-minute intervals

(7) Setup of operating constants

Sets the alarm values and the conversion constant for converting measurement data to scientific values

This setting screen manages security according to the security classifications of password administrator, setting modifier and setting visitor.

5.2 Form output

(1) Daily report

Prints the dose rate and other values (hourly values) of each monitoring post for a specified day

(2) Monthly report

Prints the dose rate (hourly values) and control standard values (average hourly values of the prior fiscal year $\pm 3\sigma$) of each monitoring post for a specified month

(3) Dose rate trend

Prints trends such as the dose rate for a specified

period

5.3 Emergency headquarters data display function

The emergency headquarters of a nuclear power plant is provided with a large-screen plasma display and an emergency system capable of displaying various types of plant information so that the plant status can be assessed accurately in the case of an emergency. Environmental radiation data is also critically important data in an emergency.

This system is provided with a function for easily outputting environmental radiation data by connecting the data monitoring device to a LAN, so that it can be linked to this emergency system.

6. Conclusion

Extremely high reliability is required of an environmental radiation monitoring system because it must perform continuous 24-hour-per-day monitoring of the area surrounding a nuclear power plant (except during scheduled system maintenance), without any data dropout. Recently, measurement data from environmental radiation monitoring systems is being transmitted to nuclear environmental monitoring facilities administered by local municipalities and is also being displayed on each power plant's website.

Within this context, Fuji Electric intends to employ such comprehensive technologies as radiation measurement, data transmission, and computer system based control to their fullest extent and to develop systems with even higher reliability to meet customer needs.

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